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This two-part article is based on a paper presented at the 2005 SMRP Conference in St. Louis, MO. It traces the design and development of standardized reliability improvement metrics that have been deployed at 35 plants across three business units and multiple manufacturing technologies within USG Corporation.

Corporation (USG) consists of five wholly-owned subsidiaries, United States Gypsum Company, USG Interiors, Canadian Gypsum Company, L&W Supply Corporation, USG Mexico and USG International. Its North American operations encompass 56 manufacturing and warehousing sites operating 34 gypsum board lines, five cement board lines, 20 joint treatment facilities, seven paper mills, nine quarries/mines and 11 ceiling product lines. The corporation employs approximately 1,800 maintenance personnel (mechanical, electrical and process controls) with an annual maintenance budget exceeding $150 million.

Asset care best practices

USG began its implementation of asset care and work management best practices in 2001. The goal of this project, which has come to be known as the Reliability Performance Model and the RPM Initiative, was to develop a world class asset management program utilizing recognized best practices that focused on the areas of equipment reliability and maintenance productivity to improve plant operating efficiencies. The aim was to change the corporation's maintenance departments from being fire fighters and emergency-based into departments that are based on prevention with controls in place to be proactive.

The resulting RPM Initiative is a structured and disciplined approach that focuses on increasing production output through equipment performance and workforce productivity improvements. Today, it continues to strongly influence the way asset care, maintenance and reliability are managed at USG's manufacturing facilities.

The work management portions of the program, work orders, planning, scheduling and shutdown coordination form the foundation of the model, as shown in Fig. 1. These are the core competencies that are the focus of the current training. All manufacturing facilities are employing planners and building central storerooms to support this effort.

USG looked to the RPM Initiative to deliver in several ways, including helping the corporation:

- gain control of our work through the work order system;
- maximize the effectiveness of the crafts via planning and scheduling; and

- begin eliminating defects by prioritizing work, assuring that the right parts, tools and employees are available to do the work so we can spend time on the most important work and performing this work right the first time.

These core competencies support USG's proactive organization, which:

- is reliability centered for developing maintenance strategies that are based on solutions to equipment failures;
- employs a database of equipment histories so we can make decisions based on accurate information; and
- utilizes well managed centralized storerooms for spare parts handling.

This work will lead to a phase where the organization builds on it successes. By putting this model into place at all USG manufacturing facilities, the company should be able to drive a culture of reliability and continuous improvement.

The initiative

USG continues to implement the RPM Initiative in phases (approximately 10 facilities each year). The first implementation began with two pilot projects in 2001 - 2002. Based on the success of those pilots, the initiative became a company -wide program. The model was then rolled out to an additional 33 facilities. The plan is to continue the implementation until all 56 manufacturing facilities have been trained and are implementing the model. Three years into the project, sites that had embraced the initiative were reporting:

1. Maintenance delays going down
2. Outages/down days better managed
3. Plant recovery rates improving
4. More project work being accomplished
5. Infrastructure repairs completed without additional costs using the savings this initiative had generated
6. Maintenance productivity up, and more work being done by smaller crews
7. Maintenance unit costs flat or going down
8. Plant output increasing

Teamwork has been a critical component to the success of this initiative. All USG employees understand that the RPM Initiative is a company- and plant-wide program—not just a

maintenance or planner program. They also understand that the production departments are integral to the success of this initiative, and their involvement has been another reason for the program's success.

Asset care metrics

Another key to the program's success has been the corporation's ability to measure maintenance performance. Relevant and standardized metrics have been developed to foster continuous improvement by involving employees at every level within the organization.

Key Performance Indicators (KPIs) and expectations were developed at the beginning of the RPM Initiative. They're what are used to drive improvements—and what USG uses to measure its performance.

The KPIs provide information on where the process is working well and where it isn't. This helps the corporation build on its successes and leads it to making process changes where unfavorable trends are developing. Table I highlights the Maintenance Benchmarks USG uses for rating various KPIs, along with the ratings for a typical USG plant.

Plant key performance indicators

During the pilot implementations, USG realized that it needed to measure the program's progress. While the organization was collecting a large amount of information in its computerized maintenance management software (currently DataStream's MP2 Access 2000) via the work order system, it realized that the data was only useful if it could be utilized to support decision making.

With the assistance of PCA, a set of Plant KPIs that focused on measuring the process and its implementation were developed. The following reflects the first 13 of the 26 KPIs currently utilized by USG.

1. Monthly Maintenance Spending (by dollar)

KPI #1 breaks out maintenance spending for labor, materials and contractors during the month.

2. Monthly Maintenance Spending (by %)

KPI #2 provides the same information as KPI #1, but shows the percentage of maintenance spending for labor, materials and contractors during the month.

Benchmark: Maintenance labor and material costs should be balanced operating close to a 50/50 split. Balanced costs indicate cost efficiency. High labor costs may indicate craftspeople are working ineffectually. High materials costs may indicate something is wrong with parts reliability or preventive maintenance.

3. Monthly Work Mix by Priority

KPI # 3 uses work order priority codes to define when a work order should be done relative to others. It calculates the percent of hours worked for the month for each work order priority (shown in Table II: Work Order Priorities), providing a clear picture of what kind of work is being done, e.g. routine, break-in, emergency or down day. Benchmark: Less than 10% of the completed work should be reactive (emergency/urgent/break-in, i.e. priorities 1, 2 and 5.)

4. Monthly Work Mix by Type (hours)

KPI # 4 is the work order type code that indicates the nature of the work performed (e.g. preventive, repair, rebuild, modify, etc.).

Each work order is coded with a work order type (as shown in Table III: Work Order Types). This KPI breaks out the work orders completed during the month by type based on actual hours charged against the work order. As with KPI #3, KPI #4 helps to provide a clear picture of what kind of work is being done.

5. Monthly Work Mix by Type Summary (%)

KPI #5 provides the same information as KPI #4, but summarizes each major work order type as a percentage of hours worked during the month.

Benchmark:40% of all hours worked should be preventive and condition based maintenance (PPM—Preventive and Predictive Maintenance).

A second benchmark measures PPM effectiveness. 15% to 30% of all hours worked should be generated from PPM inspections (FROMPM). You want your PPMs finding defects. If PPMs are not finding defects, then you may be doing the PPM too frequently or ineffectively. If you find too many defects during your PPMs then you may not be doing the PPMs often enough.

By setting these PPM benchmarks, USG is placing a priority on preventive work to drive equipment reliability improvement.

6. Monthly Work Mix by Expense Class

KPI # 6 uses an expense class code on the work order that is used to further define the type of work. It calculates the percentage of hours worked during the month for each expense class (as shown in Table IV: Work Order Classes).

7. Completed Work Orders per Man Day

KPI #7 provides the monthly trend for the past 12 months of the number of work orders completed per craftsperson.

Benchmark: Three work orders per person per day and trending up.

KPI #7 can be negatively impacted at plants where there is a high percentage of project and rebuild work thattends to be single work orders for large time commitments (e.g. 40 hours per week for a single work order).

8. Priority 1 Equipment Closed Emergency Work Orders

KPI # 8 tracks emergency work orders by the priority of the equipment. Equipment Priorities range from 1 (regulatory) to 9 (least critical) and are detailed in Table V: USG Equipment Priority Codes.

KPI #8 provides information on the number of emergency work orders completed on the plant's most critical equipment during the month. This is a "bad actor" report and it is used to help focus or direct where resources should be placed to address problems (e.g. increased inspections, preventive work, predictive work, failure analysis, etc.).

9. Equipment Other than Priority 1 with 4 or More Closed Emergency Work Orders

KPI #9 provides another snapshot of the "bad actors." It identifies equipment other than Priority 1 units with repetitive problems, as indicated by multiple emergency work orders to help identify where additional preventive work is required (e.g. increased inspection frequencies, PPM optimization, failure analysis, etc.).

10. Equipment with Costs Greater than $1000

KPI #10 is similar to the previous two KPIs as it is providing information on equipment that is expensive to maintain, to help identify where to focus efforts (e.g. review PPMs, plan capital replacements, initiate upgrades, etc.).

11. Failure Codes

KPI #11 provides information on the craftsperson's initial assessment of the cause of the failure (refer to Table IV: Failure Codes, for a partial listing of the failure codes available). This information is used to assist with root cause failure analysis, as well as to determine training needs (i.e. alignment is a common failure), PPM requirements (i.e. wear is a problem), lubrication improvements (i.e. lube failures are high), etc.

12. Job Delays

KPI #12 provides reasons for the various job delays for the month. After a work order has been completed, the craftsperson codes the work order with a job delay code. The job delay code explains what, if anything, caused a job to take longer than anticipated (i.e. charged hours are greater than estimated hours). The primary sources of job delays are interruptions (reactive issues) equipment readiness (scheduling issues), job scope changes and tools/material readiness (planning issues) and material problems (storeroom issues).

Benchmark: Zero (0) job delays due to planning, scheduling, and materials management.

13. PPM and SAR Completion Times

KPI #13 provides information on how well USG is managing its preventive maintenance and OSHA-required safety inspections (SAR), and whether the work is being completed when scheduled.

Work orders closed with $0 charged indicate that the PPM or SAR work was not completed, although it was scheduled. Plants should be evaluating why PPMs and SARs are not being completed.

Benchmark: Zero (0) PPM/SAR work orders not completed in the scheduled period. Part II of this article will appear in the next issue of Maintenance Technology. It will cover the final 13 KPIs used by USG and detail the results the corporation has seen since it began utilizing these metrics. **MT**

Table I: Maintenance Benchmarks for USG

KPI	World Class	Typical USG
% emergency/reactive work	< 10%	20%
Use of Standing Work Orders	< 5%	9%
Man-hours planned	90%	5%
Work Orders with Feedback	100%	97%
Estimating Accuracy	±10%	±20%
Schedule compliance	> 90%	77%
Backlog of work (crew-wks)	3 - 5	5 - mechanical 5 - electrical
% Backlog > 90 days old	< 5%	35%
Preventive maintenance	40%	22%
Work from PPM	15% - 30%	5%
Age of Completed Work (% 1-5 week)	15%	40%
% of Storeroom Live	100%	Best - 100% Worst - 0%
Storeroom Accuracy	98.5%	Best - 85% Worst - unknown

Table II: Work Order Priorities

Work Order Priority	Description	Explanation
1	Emergency	Work is performed immediately.
2	Urgent / Break-in	Work is performed soon and interrupts the curre
3	Routine Scheduled	This job is scheduled in a future week.
4	Down-day	This job is scheduled for the upcoming down-da
5	Down-day Add On	Added to the existing down-day schedule.
6	Down-day Pre-work	Work that is scheduled and completed before st

Table III: Work Order Types

Work Order Type Code	Field Description
ADJUST Minor	Adjustment To Equipment
ADMIN-MTG	Administrative Work Or Meeting
AUD-INSP	Audit Or Inspection
DEMOLITION	Demolition / Decommission
FABRICATE	Replacement Part Fabrication
FROMPM	PPM Feedback Corrective Work
HOUSEKEEP	Area Housekeeping
MODIFY	Modification Or Improvement
PLANNER	Maintenance Planning
PLC	Hardware Or Software
PPM	PM & PdM Maintenance Tasks
PROJECT	Project Work
REBUILD	Rebuild Or Refurbish Equipment
REMV-REPL	Remove & Replace
REPAIR	Repairing Equipment
SAFETY	All Safety Work Other Than SAR
SAR	Safety Audit Request Item
SSUG	Maintenance from Safety Suggestion
SUPV	Maintenance Supervision
TRAIN	Training
TROUBLE	Troubleshooting

Table IV: Work Order Classes

Expense Code	Field Description
CAPITAL	Capital Work Orders
ROUTINE-M	Routine Mechanical Work Orders
ROUTINE-E	Routine Electrical Work Orders
STANDING	Standing Work Orders (SWOs)

Table V: Equipment Priority Codes

Equipment Priority Code	Description

1	Mandated by law or corporate policy
2	Impacts multiple processes, runs continuous without an on-line spare, and/
3	Impacts multiple processes, runs intermittently without an on-line spare, and
4	Impacts a single process, runs continuous without an on-line spare, and/or
5	Impacts a single process, runs intermittently without an on-line spare, and/o
6	Impacts multiple processes, runs continuous with a an on-line spare, and ca
7	Impacts multiple processes, runs intermittently with an on-line spare, and ca
8	Impacts a single process, runs intermittently or continuous with an on-line s
9	Minor or no impact on safety, product, or cost

Table VI: Failure Codes (partial listing)

Failure Code	Explanation
ALIGN	Misaligned
CPLG	Coupling Failure
CRCK	Cracked
ELEC	Electrical General
GEAR	Internal gears are worn
LOOS	Loose
LUBE	Lube Fault
MECH	Mechanical General
MTCE	Maintenance Improper
NOFL	No Failure
OPTR	Operator Error
OVLD	Overloaded
SHRT	Shorted
VIBR	Vibrating
WATR	Water Damage
WEAR	Worn

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